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A METHOD AND A MACHINE FOR EXTRACTING, BY EVAPORATION, SOLID RESIDUE CONTAINED IN FLUID MATTER

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A METHOD AND A MACHINE FOR EXTRACTING, BY EVAPORATION, SOLID RESIDUE CONTAINED IN FLUID MATTER

BACKGROUND OF THE INVENTION

The present invention relates to a method and to a machine for extracting, by evaporation, solid residue to be found in suspension and/or solution in fluid matter containing volatile substances, and in particular aqueous matter.

Proposals have already been made to apply the matter for treatment in the form of a thin film on the smooth and hot face of a heat exchange wall which is heated to a temperature that is high enough to cause the water and/or other volatile substances contained in the matter to evaporate quickly, said hot wall moving cyclically around a closed path, and then to crush the layer of matter against said hot face so as to level it and encourage it to crumble and to spread, and finally, at the end of the cycle, to recover the dry, solid residue that has formed on said hot face by scraping.

A method of that kind constitutes the subject matter of U.S. Patent 5,810,975, to which reference can be made where necessary.

The machine described in that document comprises a series of horizontal disks that are parallel and on a common axis, which disks are carried by a common rotary shaft, with each of the disks constituting the moving wall, the top face of each disk constituting the hot face on which the matter is treated.

In that known implementation, matter is applied to the rotary disk by means of an oscillating arm which carries a matter-dispensing duct opening out close to the top face of the disk. The layer of matter is crushed in the embodiment described by means of a series of crushing rollers.

Scraping at the end of the cycle is performed by means of a scraper associated with a small brush, advantageously carried by the same oscillating arm as is used for

application purposes; the scraper and the small brush expel the dry residue outwards.

In the method and the machine of U.S. Patent 5,810,975, the disks and their arms are hollow, with their inside spaces communicating with one another so as to constitute a "condensation" chamber, and said set of disks is mounted inside an "evaporation" chamber, the machine being fitted with a system for extracting the vapor produced in the evaporation chamber, for mechanically compressing said vapor, and for introducing the compressed vapor into the condensation chamber, with incondensible substances being eliminated from the vapor, prior to recompression, by physico-chemical treatment.

By means of that arrangement, the quantity of heat which is given off by the vapor condensing inside the disks is transmitted to the matter by conduction through the heat exchange wall to the top face of each disk, and said quantity of heat then serves to evaporate an equivalent volume of liquid to be found in the layer of matter to be treated, which layer is spread out on said top face.

Thus, the heat given off by condensation is recovered for evaporation, thereby making it possible to work with energy input that is very low, corresponding more or less to the mechanical energy required for compressing the vapor.

That method and the machine for implementing it are particularly suited to treating farm-yard manure, in particular pig manure. The working pressure is then about 1 bar and the working temperature is about 100°C in the evaporation chamber, with a pressure of about 1.4 bars at a temperature of about 110°C in the condensation chamber.

SUMMARY OF THE INVENTION

Although the present invention is also adapted for implementation in a similar installation, where the heat generated by condensation on one face of the heat exchange wall is used to cause evaporation to take place on the

other face of said wall, the invention is not limited to such an installation.

It can be transposed to heated evaporation surfaces where the principle of mechanically compressing vapor is not implemented; under such circumstances, the method is significantly more expensive than that which relies on mechanically recompressing the vapor; nevertheless, it can be appropriate for certain kinds of matter and/or for applications in which energy consumption is not a primary concern.

Whether or not a dehydrating surface is used that is heated normally (e.g. by the Joule effect), or by using the principle of recompressing vapor, it is very important that the matter to be dehydrated is spread out in the form of a layer that is very thin and very regular on a surface that is smooth and clean.

Experiments performed by the Applicant have shown that this apparently simple objective is, in fact, very difficult to achieve with certain kinds of matter such as farm-yard manure, sewage sludge, and numerous kinds of waste from factories in the food industry.

Those kinds of waste have numerous points in common. They contain a large amount of water (about 85% to 98%), they are relatively fluid, non-uniform, and capable of settling. Their vapor carries a heavy chemical load. They give rise to major problems of corrosion and of materials behavior in general, and they also give rise to problems associated with clogging and blocking of the ducts, valves, and pumps forming parts of the machine.

Optimally, the thickness of the layer of matter deposited on the heating surface must be less than 1 millimeter (mm) and should be preferably be about 0.5 mm.

Unfortunately, the physical nature of the matter to be dehydrated makes it impossible to use conventional solutions such as nozzles, pierced manifolds, dispensing slots, or capillary coating, in particular. It is

practically impossible to apply such matter in the form of a liquid with such small thickness.

The object of the present invention is to resolve this difficulty.

To do this, the method of the invention applies the various steps described above, and is remarkable by the fact that, immediately before the matter is applied onto the hot face of the heat exchange wall, said matter is caused to expand greatly in volume, so as to give it the consistency of a foam, such that it is said foam which is applied in the form of a thin layer on the hot face. Advantageously, application is performed with a thickness of less than about 1 mm, preferably of about 0.5 mm.

This expansion in volume preferably takes place with a factor lying in the range 20 to 100.

According to a possible additional characteristic which is particularly advantageous, undesirable particles which remain stuck to the hot face after the scraping operation, are themselves eliminated so as to ensure that they do not return to the zone in which the foam is applied.

The presence of residual particles in the foam-forming zone runs the risk of causing the expander device to become clogged and of impeding the formation of foam.

Such a method is particularly adapted to treating farm-yard manure, in particular pig manure.

The extractor machine of the invention is of the above-mentioned general type and is remarkable in that the feeder and applicator means are adapted to cause the matter to expand greatly in volume and to give it the consistency of a foam immediately before it is applied, and to deposit said foam on the hot face in the form of a thin layer.

Furthermore, according to certain additional, non-limiting characteristics of the machine:

· said hot face is plane and horizontal, and the means for expanding the volume of the matter comprise both a box placed over said hot face, the box being downwardly open

and open on one side in the forward direction of advance of the moving wall, and feeder means for feeding the matter to be treated into the box, said box defining a chamber in which the matter expands, the bottom of the chamber being constituted by said moving hot face;

· the matter is fed into the box by means of a positive displacement pump via an Archimedes' screw constituted by a brush mounted to rotate in a feed duct;

· the box has a top wall whose bottom face is plane and horizontal and parallel to the hot face, said top wall being movable in a vertical direction so as to be capable of being lowered and pressed against said hot face in order to clean it;

· the machine includes means to cause said pump to stop momentarily, and simultaneously to cause the top wall of the box to be lowered and pressed against the hot face, and to do so in cyclical manner, with said top wall being raised thereafter automatically by resilient return members;

· the outline of said box when seen from above is flared, with its opening being directed in the forward direction of advance of the moving wall, and matter being fed to the upstream portion of the box, in its narrow zone;

· said crushing means comprise at least one flexible sheet which is pressed against the matter by resilient means such as a spring blade;

· said flexible sheet is driven with reciprocating motion of small amplitude;

· said flexible sheet is made of polytetrafluoroethylene;

· said scraper means comprises a battery of scrapers working in cascade, driven with cyclical motion following substantially elliptical paths;

· said heat exchange wall is a rotary disk having a vertical axis with the top face of the disk constituting said hot face, while said scrapers are arranged to transfer

the residue progressively towards the outside of the disk and to cause it to drop into a vertical collector well;

· the machine includes an additional scraper suitable for scraping the outside edge of the disk;

· it includes a fixed circularly arcuate side panel disposed beside the disk immediately downstream from the means for applying the matter on the disk and serving to prevent the foam from escaping outwards;

· it includes means for mechanically removing particles that remain stuck to said hot face, said means being situated downstream from said scraper and recovery means and upstream from the applicator means;

· said means for removing the particles comprise a pick-up metal sheet associated with at least one removal wormscrew;

· said particle removal means are adapted to evacuate said particles towards the outside of the disk;

· the machine has a set of identical horizontal disks that are closely spaced apart on a common vertical axis and that rotate together about their axis, and said machine includes a heated annular collector track disposed at the bottom of the machine, vertically beneath the edges of the disk;

· it has a set of scrapers turning synchronously with the set of disks in the collector track and adapted to transfer particles that are to be found therein towards an evacuation hole situated at the collector well;

· it has scrapers adapted to scrap off deposit adhering to the bottom faces of the disks so that said deposit drops onto the top faces of the underlying disks and/or into the collector track;

· all of the disks are hollow and are carried by a tubular shaft whose inside space communicates with the inside space of each disk, said spaces constituting a condensation chamber, said set of disks being mounted inside an evaporation chamber, the machine having a system for extracting the vapor produced in the evaporation

chamber, for mechanically compressing said vapor, and for introducing the compressed vapor into the condensation chamber;

· the machine includes a device for extracting and compacting all of the residue, e.g. a pair of hot moving endless belts; and

· the machine includes means for washing said hot face in hot water.

BRIEF DESCRIPTION OF THE DRAWINGS

Other characteristics and advantages of the invention will appear on reading the following description given with reference to the accompanying drawings which show one possible embodiment by way of non-limiting example.

In the drawings:

· Figure 1 is a simplified diagram showing the method of the invention;

· Figure 1A shows a detail of Figure 1, specifically the top wall of the foam-forming box in its low position, for the purpose of cleaning the hot face;

· Figure 2 is a diagrammatic front view of the bottom portion of an extractor machine having a stack of hollow disks;

· Figure 3 is a diagrammatic plan view of a disk;

· Figure 4 is a detail view showing the feed pump with which the machine is fitted;

· Figure 4A is a detail view of the cam shaft controlling the pump;

· Figure 5 is a diagrammatic plan view of the matter-expansion box for generating the foam;

· Figure 6 is a section view on a staggered vertical plane referenced VI-VI in Figure 5;

· Figure 7 is a fragmentary diagrammatic view of the disk, showing the crusher means which are constituted by a flexible sheet;

· Figure 8 is a diagrammatic side view of the same means;

· Figure 9 is a fragmentary plan view of the disk for showing the structure of the scraper means and for showing how they work;

· Figure 10 is a fragmentary diagrammatic view showing the system for controlling the elliptical movement of the scrapers;

· Figures 11 and 12 are respectively a diagrammatic plan view and front view of a scraper;

· Figure 13 is a diagrammatic cross-section view of one possible embodiment of means for mechanically removing particles;

· Figure 14 is a fragmentary plan view of the disk showing simultaneously the scraper means, the means for removing remaining small particles, and the means for feeding matter and forming foam;

· Figure 15 is a diagrammatic section view through the bottom portion of the machine at the bottom of the collector well and at the inlet to the device for extracting and compacting residue;

· Figure 15A is a side view of one of the scrapers that travel along the collector track, shown immediately beside the entrance to the removal hole;

· Figure 16 is a general plan view of the bottom disk and of the removal system;

· Figure 17 is a section view of the device for extracting and compressing residue;

· Figure 18 is a detail of Figure 17, showing a drive cylinder for the belt;

· Figure 19 is a plan view of the removal and compacting device, with portions thereof cut away;

· Figure 20 is a plan view of a side panel provided beside a disk; and

· Figure 21 is a cross-section corresponding to vertical section plane XXI-XXI of Figure 20.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The general principle of the method of the invention is initially described with reference to Figure 1.

By way of example, the matter to be treated is pig manure.

The matter is dehydrated on a heat exchange wall 1 which is heated to a temperature that is high enough to cause the water and/or other volatile substances contained in the matter to evaporate quickly.

The top face 10 of this wall is smooth and plane.

The wall 1 is a moving wall. It moves from left to right with reference to Figure 1, and this movement is represented by arrow R.

This movement preferably takes place at constant speed.

As explained below, when the surface 10 is the top surface of a disk, the movement R is constituted by continuous rotation at a slow speed.

It is thus constituted by movement that is cyclical, with matter being deposited on the hot face 10 at the beginning of the cycle, and with the various kinds of residue being removed by the end of the cycle so that the face 10 is clean when it returns to the station for applying the matter to be treated.

As explained below, this station 2 is generally in the form of a box and its top wall is referenced 20. This box is open downwardly and on one side, specifically downstream, i.e. the side corresponding to the forward direction R.

The matter is brought to the box by means that are described below, including an Archimedes' screw 21 mounted to rotate in a tube. The section of the matter feed duct is relatively small relative to the volume available for the matter inside the volume of the box 2. That is why the matter vaporizes in part and expands rapidly, thereby becoming transformed into an emulsion that takes on the consistency of a foam.

Depending on the nature of the matter, the foam can be more or less dense. The box is shaped and dimensioned in such a manner that expansion takes place in a ratio lying in the range 20 to 100. This means that the volume of foamy material formed inside the box 20 is 20 to 100 times greater than the volume of the matter that is introduced therein by the Archimedes' screw 21.

As this emulsion evaporates progressively, as represented by arrows E in Figure 1, a layer is obtained that is of increasing dryness and decreasing thickness.

This layer encounters crusher means 3 whose function is to encourage crumbling and spreading out of the layer of matter against the hot face, so as to make said layer uniform by flattening out the small craters that have formed therein, thus having the effect of considerably improving the quality of heat exchange between the hot face and the matter.

These crusher means are described below with reference in particular to Figures 7 and 8.

At the end of dehydration, the layer comprises residue that is dry or nearly dry. That is when the scraper means 4 come into action to scrape off the residue r so as to expel it from the surface 10, directing it towards collector means.

The scraper means are described in greater detail below with reference in particular to Figures 9 and 10.

In spite of this operation, small particles p still remain on the hot face 10.

Some residue inevitably escapes from the action of the scraper means, in particular because it adheres strongly to the hot face. Other particles p are pieces of residue that were indeed caught by the scraper means, but have become detached therefrom.

It is important to eliminate these undesirable particles p so that they do not return to the foam-forming box, since they would clog it up quickly and impede the expansion phenomenon.

To this end, means 5 are provided between the scraper members 4 and the box 2 for the purpose of removing these particles p and expelling them from the hot face 1.

These means are described below, with reference in particular to Figures 13 and 14.

As shown in Figure 1A, it is possible to clean the face 10 periodically by lowering the top wall 20 of the box so as to press it with a certain amount of force against the face 10. This action has the effect of breaking up any aggregates that are forming, which aggregates are constituted by heavy sediment or partially dried-out matter adhering very strongly to the face 10.

Figure 2 is a highly diagrammatic view of part of a rotary disk dehydrator machine of the same general type as that described in above-cited U.S. Patent 5,810,975.

That machine comprises a vessel 6 having insulating walls 60 of generally cylindrical shape about a vertical axis ZZ' and supported by a stand 61 fixed to the ground.

Inside the vessel 6 there is mounted a stack of hollow disks 1 in a horizontal disposition, the disks all being mounted on a common tubular shaft 100 about the axis ZZ'.

This assembly is guided in rotation in a guide device 101 carried by the bottom wall 62 of the vessel.

The inside volume of the tubular shaft 100 and of the hollow disks constitutes a condensation chamber, while the space outside the disks and inside the vessel constitutes an evaporation chamber.

The vapor taken from the evaporation chamber is recovered, compressed mechanically by means that are not shown, and introduced into the condensation chamber, as symbolized by arrow a.

The condensate is recovered in a receptacle 63 mounted at the bottom of the tubular shaft 100 and is periodically removed as represented by arrow b.

As an indication, a set of 20 to 30 disks is provided with each disk having a diameter of about 2 meters (m).

The hollow shaft 100 is rotated by appropriate means (not shown) continuously and uniformly at a relatively slow speed, e.g. about 0.33 revolutions per minute (rpm).

On observing Figure 2, there can be seen an annular track 7 which is fixed inside the vessel, on its bottom 62. This track is in the form of a circular, upwardly-open channel section and it lies beneath the outer edge of the stack of disks.

It will be understood that any matter expelled outwards from each disk can fall under gravity into the track 7.

A plurality of scraper members 71 are mounted in the track 7. These members are regularly spaced apart angularly and they are carried by an additional disk 72 that is also mounted to rotate about the axis ZZ'.

Advantageously, the bottom disk 72 is secured to the hollow shaft 100 so that it turns together with the disk.

On the left of Figure 2, there can be seen an electric motor and gear box unit 48 with an outlet shaft referenced 47.

As described below this rotary shaft serves to drive a pair of arms 44, 44' with reciprocating motion, the arms carrying the above-mentioned scraper means.

The general plan view of Figure 3 shows how the various stations are situated on each disk 1, with the direction of rotation being symbolized by arrow R.

In this figure, there can be seen a pump 213 for feeding matter to the Archimedes' screw 21, the box 2 in which the foam expands, the crusher means 3, the scraper means 4, and the means 5 for removing undesirable residual particles. There can also be seen the annular track 7 which has a set of scrapers 71 traveling therealong, together with a small brush 710 whose function is to sweep the tops of the scrapers clean as each of them goes past the brush.

In Figure 3, there can also be seen a vertical collector well 8 and a side panel 12 whose functions are described below.

Figure 4 shows the device for feeding matter to be treated, which matter is at a temperature close to its dehydration temperature, which for manure is a temperature close to 100°C.

Advantageously, prior to being fed in, the manure is warmed by means of the distillate that results from the evaporation treatment, the manure passing through a heat exchanger in which the manure and the distillate circulate as counterflows relative to each other.

A heat exchanger suitable for performing such prior warming constitutes the subject matter of patent application No. 99/00655 of January 14, 1999, to which reference can be made, where necessary.

The matter is fed by means of a positive displacement pump 213 whose characteristics, and in particular whose delivery rate are selected to be compatible with the drying area and with the nature of the matter; when dealing with manure, it is possible to use a pump of the type having an eccentric rotor, delivering at a rate lying in the range about 25 liters per hour (l/h) to 50 l/h.

The function of the Archimedes' screw 21 is to introduce the matter into the box 2, and it comprises a tube 218 having a helical brush 217 turning therein to constitute the screw proper; this solution is particularly suitable for avoiding dirtying and clogging.

The pump 213 is fed by a matter delivery duct 210 via a three-port valve 212. The device also has a hot water feed 211, so that by actuating the valve 212 it is possible to feed the pump selectively either with matter to be treated or else with hot water (for the purpose of performing a cleaning sequence).

The pump 213 is rotated from a gearwheel 216 itself driven by a motor (not shown) via a clutch. The clutch has

a driving claw resiliently biased by a helical compression spring 215.

It is possible to declutch the pump from the drive gear 216 by turning a cam shaft 200, declutching occurring when the cam 201 of the cam shaft presses against a rod 217 secured to the driving claw. This serves to cause the feed of matter to the box 2 to be controlled in cyclical manner.

As shown in Figure 4A, the shaft 200 carries a plurality of cams 201 which are angularly offset, and uniformly distributed along the longitudinal direction of the shaft. Each disk is associated with a pump that is stopped by a corresponding one of the cams. The angular offset enables the cleaning cycles to be offset from one disk to another so that overall dehydration takes place in uniform manner within the machine.

The Archimedes' screw 21 opens out into the box 2, which is shown in detail in Figures 4 and 5.

The box 2 is constituted by a frame 22 which is flared in shape when seen from above. It comprises a vertical partition which is in contact with the hot face 10 via a gasket 23.

The box has a horizontal wall 20 referred to as its "top" wall (since the box is upside-down with its opening facing downwards), situated at a certain distance from the face 10, and the entire assembly is made of thermally insulating material.

The bottom face 2000 of this top wall is plane, smooth, and parallel to the face 10.

This plate 20 is held in a high position by springs constituted by resilient wires or blades 25 pressing the plate upwards against abutments 24; these abutments are constituted by pads of semicircular outline that are uniformly distributed and fixed to the top of the frame 22.

A flexible membrane 26 has one of its edges fixed to the top of the frame 22 and has its other edge fixed to the adjacent bottom margin of the top wall 20, providing sealing at this point.

Seen from above, the partition 22 is symmetrical in shape, being approximately V-shaped with limbs that diverge in the forward direction R. The limbs of this V-shape are slightly arcuate, with their convex sides looking into the box.

The feed screw 21 opens out into the narrow zone 23 corresponding to the point of the V-shape.

The relatively dense matter delivered by the Archimedes' screw 21 into the zone 29 of the box thus enters a flared space defined on top by the top wall 20, on the sides by the diverging partitions 22, and downwards by the moving hot face 10, with this space being open at the other side in the forward direction R.

As can be seen in Figure 3, the mouth of this V-shaped box extends substantially radially over the entire width of the disk between its central shaft 100 and its outer edge.

Because of the instantaneous partial vaporization that occurs due to the temperature of the face 10, because of the volume available for expansion, and because of the drop in pressure, the matter M is transformed into an emulsion with bubbles being generated so it takes on the consistency of a foam.

This foam is spread out over the entire radius of the moving disk.

A pair of projections 28 are mounted on the top wall-forming plate 20.

These projections constitute cam followers which, on each revolution, come into contact with cams 282 fixed to the bottom face of the disk situated immediately above, which cams bear against the projections 28 so as to cause the top wall 20 to moved downwards (arrow P) and press it against the surface 10.

After this cam 280 has gone past, the resilient members 25 cause the plate 20 to rise automatically, and come back into abutment against the pads 24.

The stopping of the pump under the control of the cams 201 as described above is naturally synchronized with the

lowering of the top wall 20 of the housing so that matter feed is interrupted during the length of time that the plate 20 is rubbing against the surface 10.

The disk is thus cleaned on each revolution, i.e. once every 3 minutes, and cleaning takes place during a period of a few seconds.

In addition to providing this frequent cleaning, it is possible to provide additional cleaning using hot water, e.g. once every 3 to 6 hours, with hot water taking the place of the matter that is be dried, either selectively on a disk-by-disk basis using the three-port valve 212, or else collectively for all of the disks together. This additional cleaning with hot water advantageously lasts for one or two revolutions, i.e. for a period of time lying in the range 3 to 6 minutes.

Cleaning each disk separately minimizes disturbance to the overall operation of the machine.

Such cleaning is also performed each time the machine is started up and each time it is stopped.

Hot water cleaning is necessary for eliminating the buildup of dirt that inevitably occurs with certain kinds of matter that are particularly difficult to treat, and which deposit a very thin film on the disk after a few hours of operation, which film is capable of significantly degrading the effectiveness with which dehydration takes place.

It is important to ensure that the foamed matter does not escape over the edges of the disk on leaving the box 2.

For this purpose, a side panel is located immediately downstream from the box 2.

With reference to Figures 20 and 21, it can be seen that the side panel 13 is constituted by a pair of circularly arcuate strips disposed concentrically with the disk, and disposed on either side of a flexible tape 12. The tape is pressed against the edge of the disk and constitutes a sealing wall that prevents matter from spilling over away from the disk. The side panel is

carried by a shaft 140 placed at the end of a resilient blade 14 whose other end is supported by a fixed part. The resilient blade 14 presses the gasket 12 against the top face of the disk with a certain amount of force. The wall 12 is made of flexible synthetic material that withstands being corroded by the matter.

This side panel extends over a sector of limited circumference, since there is no need for it once the matter has been channeled and has begun to dehydrate.

An advantageous embodiment of the crusher means 3 is described below with reference to Figures 7 and 8.

These means comprise a V-section bar 30 which is fixed at one of its ends to a rather stiff bending blade 34; the blade 34 lies approximately at the half radius position across the disk and it extends in the general forward direction of the disk in said zone. It can bend in a horizontal plane. The other end of the blade 34 is fixed to a support 33 that is secured to a fixed part 400. It has the function of guiding an arm 40 in translation while leaving it with a certain amount of freedom for angular movement, which arm 40 constitutes the scraper means 4 that are described below. The arm 40 is represented by chain-dotted lines in Figure 7 and moves with reciprocating motion centered on the part 400 and of small amplitude d.

The ridge of the V-shaped bar 30 faces upwards, and the bar has one web that is vertical while its other web slopes downwards and downstream (relative to the forward direction R of the disk).

A strip of resilient stainless steel sheet 31 is fixed under the sloping flange and partially overlies a broad sheet 32 of polytetrafluoroethylene (PTFE).

This PTFE sheet 32 is pressed hard against the top face of the disk.

The metal strip 31 and the PTFE sheet 32 are in the form of elongate rectangles each with a long side corresponding to the length of the bar 30 that supports them.

The long side 32 is at a small acute angle α relative to the radial direction. This is a reentrant angle relative to the center zone of the disk, tending to direct matter more towards the center of the disk than towards the outside thereof, where there would be a danger of some of it escaping.

The end of the bar 30 which faces towards the center of the disk has a cam 35 fixed thereto, which cam is normally in contact with the above-mentioned oscillating arm 40.

Consequently, its reciprocating motion is transferred by a cam 35 to the flexible sheet 32 which thus also describes reciprocating motion. By way of indication, the amplitude of this motion can be about 10 mm to 30 mm. The PTFE sheet 32 is returned by the elasticity of the blade 34.

The moving broad PTFE sheet crushes the craters and other roughnesses of material, flattening them, thus making it possible to obtain a layer that is thin and uniform over the entire width of the disk, thus ensuring good transfer of heat and excellent drying.

With reference more particularly to Figures 9 to 12, the structure and the operation of the scraper means is described in greater detail.

These means comprise a set of scrapers which, in the example shown, are four in number and are referenced 41a, 41b, 41c, and 41d. The scrapers are regularly spaced apart and placed on a line that is close to being radial, the first scraper 41a being situated in the center zone (close to the hub 100), while the last scraper 41d is in the outer zone of the disk.

Each scraper is mounted at the end of a spring blade 43 carried by the above-mentioned arm 40.

It is constituted by an angled horizontal arm whose free end extends beyond the central portion of the disk and it is guided in translation with a certain amount of angular freedom in the above-mentioned part 400.

The bend at the opposite end referenced 44 is extended by a crank 45 whose movement is controlled by an eccentric gear 46b.

This gear meshes with a driving gear 46a carried by a drive shaft 47.

The shaft is rotated at a continuous and uniform speed by the above-mentioned motor 48 shown in Figure 2.

Each scraper 41 is pressed against the top face 10 of the disk by its spring blade 43.

The blade presses hard against the scraper via a ball 430 which is welded under the spring blade.

In the example shown (Figures 11 to 12), the scraper 41 has two lateral scraper blades 42.

These blades are preferably made of a metal that is very hard and that has a good coefficient of friction, for example tungsten carbide.

The position of the scraper relative to the spring blade 43 is adjustable by means of a link finger, e.g. a threaded finger 431 (represented solely by means of its axis in Figure 12).

By means of this disposition, where the ball 430 forms part of a ball and socket joint, it is possible to press the scraper blades appropriately against the surface of the disk even if the surface is not accurately plane.

As can be see in Figure 9, the various scrapers are placed along a line that is at an angle relative to the accurately radial direction of the disk.

The outer scraper 41d is further downstream on the disk than is the preceding scraper 41c, and so on to the inner scraper 41a.

Because of the movement imparted by the crank system 41b/45, each scraper follows a closed oval path that is approximately elliptical in shape, and that is represented in fine lines in Figure 9. The various paths t_a, t_b, t_c, and t_d overlap one another so the scrapers operate in cascade.

Thus, residue unstuck by the first scraper 41a anywhere on the path of said scraper is transferred to the following scraper 41b; this scraper in turn transfers to the next scraper 41c the sum of its own residue plus the residue it has received from the first scraper, and so on to the last scraper 41d.

The last scraper expels the residue out from the disk into a vertical well 8 of semicylindrical section situated at the edge of the disk facing the scraper 41d.

Each disk is associated with such a battery of scrapers, and all of them terminate looking into the well 8.

The residue taken from all of the various disks is thus removed via the same vertical well 8 which serves to collect it. The residue drops to the bottom of the well under gravity.

As can be seen in Figure 10, the same gearwheel 46b drives two arms, specifically the arm 44 described above and the arm 44' of the disk situated immediately above.

The two cranks corresponding to the arms 44 and 44' are located at diametrically opposite points on the driving gearwheel 46b so as to balance the forces on the hubs of the gears 46a, 46b appropriately.

The same applies to the entire set of disks, with a single drive mechanism being associated with a pair of scraper assemblies.

In Figure 9, it can be seen that the arm 40, 44 carries four elements referenced 441.

These elements carry upwardly-facing scrapers that can be similar in configuration to the scrapers described above.

They are situated slightly upstream from the scrapers 41.

These scrapers serve to scrape the underside of the disk situated immediately above, where matter also becomes deposited due to the large volume of the foam that leaves the box at the beginning of the cycle, with this abundant

foam being capable of coming into contact with the disk above.

The residue scraped off by the scrapers 441 drops onto the disk and forms part of the residue removed by the scrapers 41 into the collector well 8.

It should be observed that immediately upstream from the collector well 8 there is provided a scraper blade 80 which presses against the cylindrical edge of the disk.

Deposit eliminated by the blade 80 falls under gravity into the underlying track 7.

It should be observed that the deposit present on the underside of the disks and on the outer edges thereof is of a chemical composition that is different from the basic matter; the bubbles that produce this deposit does not contain any sediment; however they do contain solid substances, in particular sodium and potassium chlorides.

As the deposit becomes thicker, it becomes impossible to dry it; it remains in a moist condition on the undersides of the disks and on the outer edges, and it is capable of corroding stainless steel quickly.

The secondary cleaning performed by the scrapers 441 and 8 serves to ensure that the chloride layers remain very thin and dry, and therefore non-corrosive.

On leaving the scraper assembly 4, not all of the dry residue is completely recovered. Small particles of undesirable residue remain on the disk, which particles are sticky to a greater or lesser extent and some of them are particles that have become detached from the scrapers. These particles need to be removed and directed into the collector track 7.

If this is not done, the back of the foam-generating box becomes completely clogged up after working for a few hours.

To solve this problem, the machine is fitted with means for removing these particles, which means are shown in Figures 13 and 14.

These means 5 comprise a metal sheet 50 that is fine, hard, and resilient.

This is an elongate metal sheet folded transversely approximately into a U-shape with the opening facing upstream and sideways, and it extends substantially parallel to the line of scrapers 41, immediately downstream from said line.

The bottom limb of the U-shape, referenced 500, presses accurately against the face 10 and acts as a scraper knife which picks up the particles as they arrive.

The metal sheet 50 constitutes a kind of cover having a transporting wormscrew 51 mounted therein and rotated under drive from an end gear 53 meshing with a suitable driving gear (not shown). This wormscrew is guided at its ends between bearing-forming parts secured to the adjacent box 2.

The wormscrew is made of stainless steel and its thread is very smooth; it rotates in such a direction as to convey the particles intercepted by the scraper knife 500 and retained by the cover 50 towards the outside of the disk.

It is preferable to use two oppositely-handed meshing wormscrews 51 and 51', as shown in Figure 13.

The particles conveyed by this device are transferred to the outside of the disk and fall like the other particles under gravity into the annular track 7.

As can be seen in Figure 15, the collector well 8 opens out at its bottom end into a circular opening 81 provided through the bottom wall of the track.

An extractor and compactor device 9 is installed beneath the hole 81 and acts on all of the residue that has been removed form the disk by the various means described above.

In side view, Figure 15A shows one of the scrapers 71 that travels continuously along the track 7.

It is constituted by a resilient blade, e.g. made of spring steel, whose top portion is secured to a mounting part 710 fixed beneath the drive disk 72.

The blade 71 slopes downwards and upstream, and its free bottom end is folded through a right angle so as to scrape the various particles p found on the track and bring them to the hole 81 through which they drop into the extractor device 8.

Because the scrapers 71 pass periodically through the collector well, they become dirtied by the residue dropping down the well, which is why a small cleaning brush 710 is provided, as mentioned above with reference to Figure 3.

The extractor and compactor device 9 has a pair of conveyor belts 90 and 91.

These are horizontally-extending endless belts. The bottom belt 90 is longer than the top belt 91 and the portion of its top strand that is not covered by the belt 91 passes beneath the hole 81.

The endless belts 90 and 91 are metal belts driven at their downstream ends by drive cylinders 900 and 910 respectively; upstream end deflector cylinders are given respective references 901 and 911, with their directions of rotation being represented by respective arrows m and n.

These belts pass over intermediate heater plates 95, 96 respectively which are capable of withstanding high pressure, so as to compact and extract the collected residue, while also finishing off drying thereof.

The traction forces applied to each of the belts can exceed 1000 decaNewtons (daN). That is why the metal belts are mesh belts, and the cylinders 900 and 910 are fitted with peripheral studs 913 suitable for engaging in the mesh.

The drive cylinders 910, 900 carry end gears 931 (see Figures 18 and 19) which mesh with each other so as to ensure that both belts move synchronously at the same speed; the belts are driven by a motor and gear box unit 94 whose outlet shaft 95 carries a driving sprocket wheel

engaged with the driving cylinders via a transmission chain 930.

The two belts can be parallel, as shown in the figures, or else they can converge slightly so as to compress the matter as it travels towards the outlet, thereby compacting it.

After being compacted, the residue leaves in the form of a cake via an adjustable die 950 referred to as a "knife-die".

The belt device is installed in a housing referenced 97; the knife-die is sealed relative to said housing by gaskets 951.

Sealing relative to the evaporation chamber of the dehydration vessel is provided by the dried matter itself since this matter is sufficiently compacted in the die to provide this sealing, which is essential.

Naturally, the diameter of the rollers 910, 900, 911, 901, the gap between the two belts, the slope of the belts, the width and the travel speed thereof are all adapted to the nature and the flow rate of the matter to be extracted.

The function of this extractor device is to remove all of the residue that has passed through the opening 81, to compact it, and to deliver it to the outside of the machine while providing sealing against vapor, since the evaporation chamber whose temperature is about 102°C, for example, is at a pressure higher than atmospheric pressure outside it, and by way of indication this higher pressure can lie in the range 50 Pascals (Pa) to 100 Pa.

The method, the machine, and the installation as described above are particularly suitable for treating farm-yard manure, and more specifically pig manure.

Nevertheless, they can be transposed to various other applications, for treating a variety of kinds of matter, for example sewage sludge or waste from factories in the food industry.